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INSTRUCTIONS

FOR THE

BEAT FREQUENCY GENERATOR

TYPE 140-A

BOONTON RADIO CORPORATION
BOONTON, NEW JERSEY
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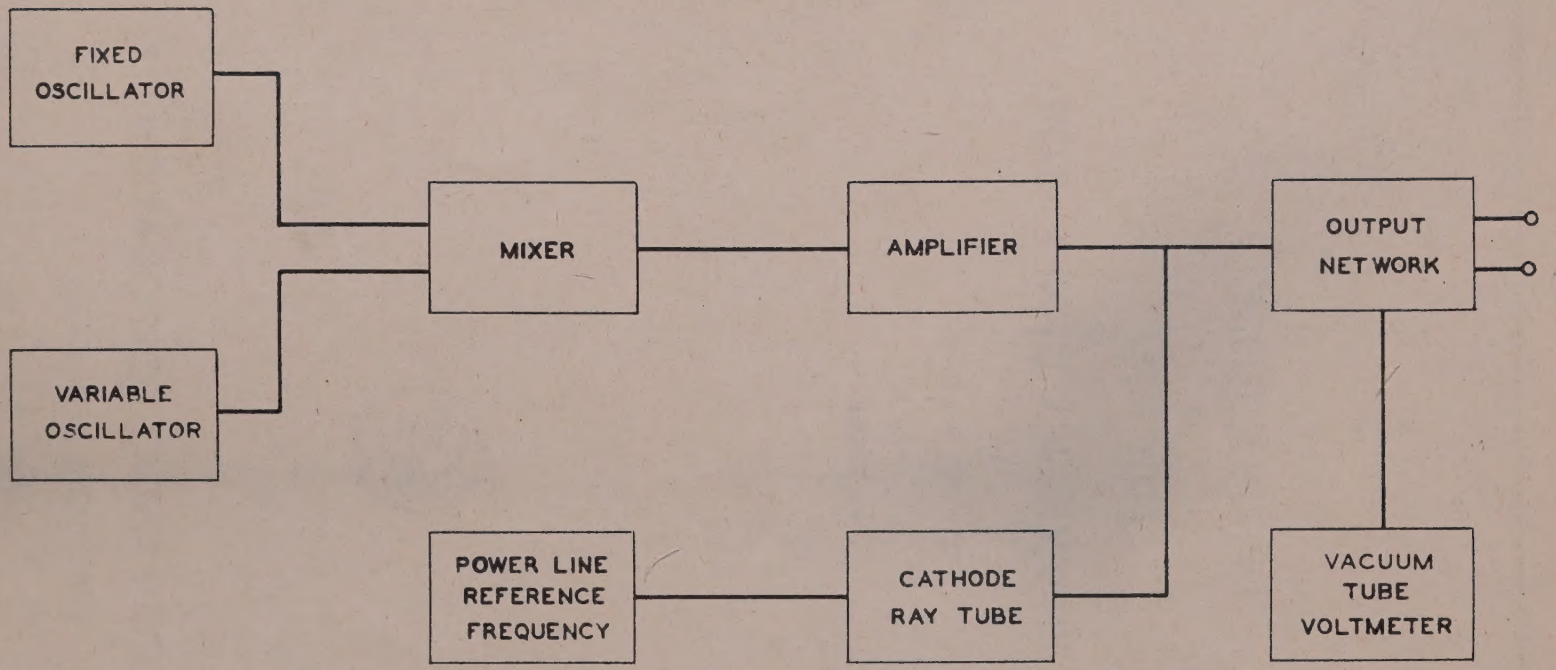


FIG. 1 - BLOCK DIAGRAM

SECTION I

GENERAL DESCRIPTION AND SPECIFICATIONS

The type 140-A Beat Frequency Generator is a compact, a.c. operated generator which will supply a continuously variable voltage of from 1 millivolt to 32 volts over a continuously variable frequency range of from 20 cycles to 5 megacycles (in two ranges) at its output terminals.

The fundamental circuit (Fig. 1) consists of a two range, differential, double oscillator system (one fixed, one variable) and mixer, followed by a gain controlled, wide band, flat amplifier, terminating in a multi-purpose output system comprised of (a) a five position decade resistance attenuator, (b) a five position tapped transformer output and (c) a "power" position for use with an external dissipative load. A cathode ray tube facilitates setting the variable oscillator to zero frequency or to multiples or submultiples of the power line frequency. A VTVM measures the output voltage.

OSCILLATORS:- Both the fixed and variable oscillator circuit are closely identical in design, so that irrespective of fundamental frequency drifts due to heating, etc., the differential or beat frequency will remain substantially constant.

For the low frequency range, the fundamental frequency of the fixed oscillator is set at approximately 200 k.c., the variable oscillator being tunable between 200 k.c. and 170 k.c.

For the high frequency range, the fixed oscillator is set to approximately 23 mc, the variable oscillator being tunable between 23 mc and 18 mc.

Independent external controls of the small variable condenser for zero frequency setting of each frequency range are mounted on the front panel (Fig. 2 #C11 and #C17). In parallel with each of these are two larger variable condensers for screw driver adjustment (Fig. 2 #C12 and #C16). These are factory adjusted to insure adequate range of the external zero adjusting condensers.

MODULATOR:- A small voltage from the fixed oscillator is applied to #1 grid of the multi-grid modulator tube. A voltage sufficient to saturate the #3 grid is applied from the variable oscillator. This combination of applied oscillator voltages results in a substantially constant modulator output with low distortion. Control of the voltage applied to #1 grid and equalization of modulator output for both frequency ranges is obtained through the variable condenser (Fig. 3 #C32). Transmission of the oscillator fundamental frequency is attenuated by means of filters.

AMPLIFIER:- The three stage amplifier is resistance coupled, frequency compensated with a response substantially flat between 20 cycles and 5 megacycles. Distortion is reduced by operating the last two tubes at constant gain and balancing the second harmonic generated in the output tube with that generated in the driver tube. The third harmonic generated in the output tube increases as the output power is increased above the rated one watt.

A continuously variable output voltage control is interposed between the first and second amplifier tubes (Fig. 2 #R28) and due to circuit design, causes little frequency discrimination.

ATTENUATOR-OUTPUT SYSTEM:- Extreme flexibility has been provided by incorporating three distinct types of output circuit. An 11 position output switch (Fig. 2 #S4) selects the various steps of each type of output as follows:

ATTENUATOR SWITCH SETTING	RATED MAX. OUTPUT VOLTS	APPROX. INTERNAL RES.	RATED FREQ. COVERAGE	TYPE OF OUTPUT CKT.
x .0001	.003	1 ohm		
x .001	.032	1 ohm	20 cycles	
x .01	.32	10 ohms	to	Resistance
x .1	3.2	100 ohms	5 mcs.	
x 1.	32.	1000 ohms		
	VOLTS FOR 1 WATT	FOR EXTERNAL IMPEDANCE OF		
20 ohms	4.5	20 ohms		
50 ohms	7	50 ohms	20 cycles	
200 ohms	14	200 ohms	to	Transformer
500 ohms	22	500 ohms	30 kcs.	
1000 ohms	32	1000 ohms		
	RATED MAX. OUTPUT VOLTS	FOR EXTERNAL IMPEDANCE OF		
PWR*	32	1000 ohms	20 cycles to 5 mcs.	Impedance

* Alternately, 72 ohms Output (see page 13).

RESISTANCE OUTPUT:- Voltage range continuously variable between 1 millivolt and 32 volts, over the entire frequency range. Voltages between attenuator steps are obtained by setting a continuously variable gain control. When maximum output from the attenuator is used, the voltmeter reads the instrument terminal voltage, and when steps of the attenuator are used, the voltmeter times the attenuator factor indicates the open circuit terminal voltage.

TRANSFORMER OUTPUT:- A tapped output transformer, operating over a frequency range of from 20 cycles to 30 kilocycles, provides a continuously variable 10:1 voltage range (100:1 power range) on each transformer tap with a maximum power capacity of approximately 1 watt, into various external impedances. The VTVM reads directly the voltage across the output terminals on each step of the transformer.

IMPEDANCE OUTPUT:- For use with an external dissipative load. With an external load resistance of 1,000 ohms, a continuously variable power range of from .01 to 1 watt, corresponding to 3.2 to 32 volts, approximately, may be obtained over the entire frequency range. The VTVM reads directly, the voltage across the output terminals on the "PWR" step of the attenuator.

POWER UNIT:- The power unit incorporates a dual voltage transformer for operation on either 115 or 230 volts, 50 - 60 cycles. A "115-230" changeover switch with lock (Fig. 2 #S2) permits setting for the available power line source. A "Hi-Lo" switch (Fig. 2 #S3) provides for operation on power line voltages approximately 5% higher or lower than normal. Power consumption is approximately 120 watts.

CAUTION:- The proper power line voltage and frequency to correspond with the setting of the "115-230" switch, must be used.

VOLTMETER ACCURACY:- Generally better than 3% of full scale rating between 20 cycles and 5 megacycles. The VTVM tube used is the special BRC type 101-D tube and is interchangeable without recalibration. The voltage scale is substantially linear. A zero adjustment is provided on the front panel (Fig. 2 #R48).

FREQUENCY:- When properly adjusted (see page 7) the frequency calibration is accurate to approximately 2 cycles up to 100 cycles and 2% above 100 cycles.

FREQUENCY STABILITY:- With reasonably constant room temperature the maximum frequency drift, on the low frequency range, is not more than five cycles, below 1,000 cycles. With increasing frequency, the drift becomes a negligible percentage. On the low frequency end of the high frequency range, the drift will not exceed 2 or 3% and with increasing frequency also becomes a negligible percentage. The frequency drift may be corrected at any time (see page 7).

OUTPUT VOLTAGE CONSTANCY AND STABILITY:- With rated loads and with constant power line voltage, the output voltage is constant within about 2 DB over the rated frequency ranges. With capacitive loads exceeding 20 mmf. the variation will be greater. A 10% power line voltage change produces approximately 20% output voltage change.

WAVEFORM:- (Resistance output). At full rated output, individual harmonics, in general, are less than 5% of the fundamental over the entire frequency range. When the output voltage of the output tube is reduced to one-half or less, the individual harmonics are reduced and, in general, are less than 2% of the fundamental over the entire frequency range.

STRAYS:- Extraneous voltages such as voltages of fundamental oscillator frequency, harmonic beats, and ripple are less than 1% on all attenuator settings for gain control settings exceeding one-tenth of maximum voltage ratings.

SHIELDING AND FILTERING:- Adequate magnetic and static shielding is provided to prevent pick up by amplifiers of ordinary sensitivity. Filtering of power line leads is such that at full rated output (32 volts), the strays on the power line are but a few millivolts.

SECTION II

INSTALLATION AND OPERATION

After unpacking and inserting the tubes, the instrument is ready to operate. The "ON-OFF" switch is indicated in Fig. 2 #S1.

CAUTION:- Only the proper power line voltage and frequency to correspond with the setting of the "115-230" switch (Fig. 2 #S2) must be used. Set "Hi-Lo" switch (Fig. 2 #S3) to "Hi" unless inadequate output is obtained due to low line voltage.

INSTALLING TUBES:- Tube sockets may be reached for insertion of tubes by opening rear door of the cabinet and removing the rear guard plate.

The Type 913 Cathode Ray Tube may be removed by (1) lifting hinged door in top of cabinet, (2) removing top guard plate (containing nameplate), (3) removing CRT guard sleeve and, (4) pushing the 913 forward and out of socket and then withdrawing the tube. The CRT guard ring need not be removed.

CAUTION:- The CR tube guard sleeve is necessary due to the high potential on the metal frame of the CR tube and should be placed over the CR tube BEFORE it is placed in the socket.

Some of the tubes supplied with the instrument are selected tubes and are marked with an identification number. The identification numbers indicate their proper location in the instrument, e.g., tube V1 is to be installed as shown in the photograph (Fig. 2) etc. The tube complement is as follows:-

IDENT. NO.	TYPE NUMBER OF TUBE AND USE		SEE NOTE
V1	6V6-G	Variable oscillator	1
V2	6V6-G	Fixed oscillator	1
V3	6L7-G	Modulator	1
V4	6V6-G	First amplifier	1
V5	6V6-G	Second amplifier	1
V6	6L6-G	Power output	1
V7	913	Cathode ray tube	2
V8	101-D	BRC VTVM tube	2
V9	5V4-G	Power rectifier	2

Note 1. Selected for best operation. Insert in socket as indicated.
Note 2. May be replaced with standard tube of same type number.

Selected replacement tubes may be obtained from Boonton Radio Corporation.

FREQUENCY CALIBRATION ADJUSTMENT:- For ordinary work, the oscillator system may be adjusted to zero frequency on each frequency range by setting the frequency dial (Fig. 2 #C10) to zero and adjusting the "ZERO ADJUST" control knob for each frequency range (Fig. 2 #C11 and #C17). Zero frequency is indicated by both (a) zero output volts on the VTVM and (b) a stationary horizontal line on the cathode ray tube (Fig. 2 #V7). The cathode ray tube is so connected that a voltage of the output frequency is applied to the vertical deflecting plates and a voltage of the power line frequency is applied to the horizontal deflecting plates. A more accurate frequency adjustment may be obtained (a) on the low frequency range by setting the frequency dial (Fig. 2 #C10) to the power line frequency (assuming it is accurately known) and adjusting the "ZERO ADJUST" control (Fig. 2 #C17) until the output frequency of the instrument is synchronized with the power line frequency, which is indicated by an elliptical pattern on the cathode ray tube. Multiples or sub-multiples of the power line frequency may also be used and identified by the Lissajous figures and (b) on the high frequency range by beating with an accurately known frequency such as the carrier of a broadcast station, using the same technique.

FREQUENCY DRIFT:- At any time, the frequency drift may be compensated and calibration restored by repeating the FREQUENCY CALIBRATION ADJUSTMENT.

CATHODE RAY TUBE:- The cathode ray tube (Fig. 2 #V7) is connected to the generator output tube plate circuit so that it indicates output voltages from about 50 kilocycles down to zero frequency. The control (Fig. 2 #R49) varies the focus and intensity of the cathode ray tube.

CAUTION:-* This control should be used to extinguish the beam and to preserve the tube screen when not used for frequency calibration.

NOTE:- A distorted wave form will be obtained on the cathode ray tube (a) if the power line voltage is non-sinusoidal or distorted by a line voltage regulator of the saturated core type or (b) if the instrument is generating a distorted voltage.

VACUUM TUBE VOLTMETER:- Zero adjustment of the VTVM (Fig. 2 #M1) is made by means of the VM ZERO control (Fig. 2 #R48). This adjustment should be made with the output control (Fig. 2 #R28) turned counter clockwise as far as possible or with the generator frequency set at zero.

* See also page 11.

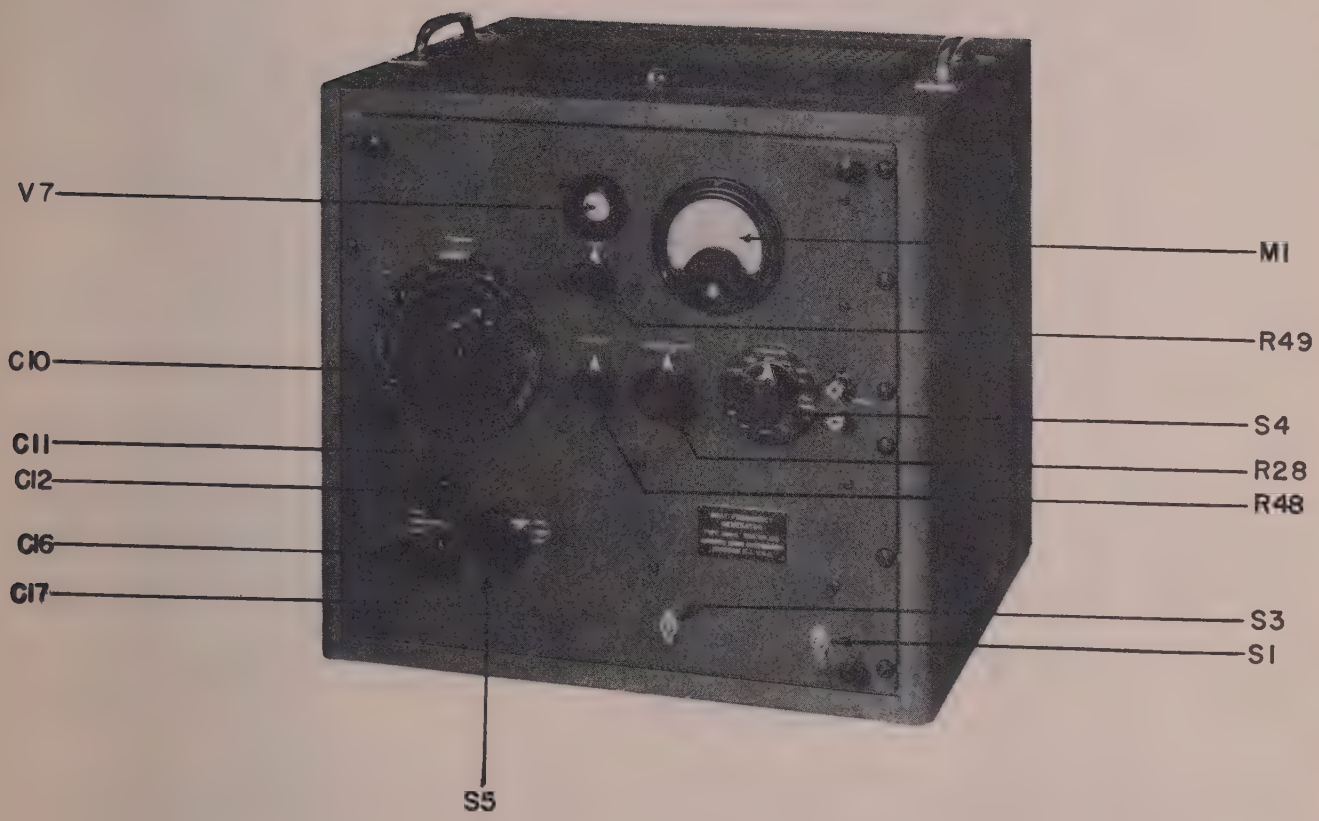


FIG. 2 - FRONT VIEW

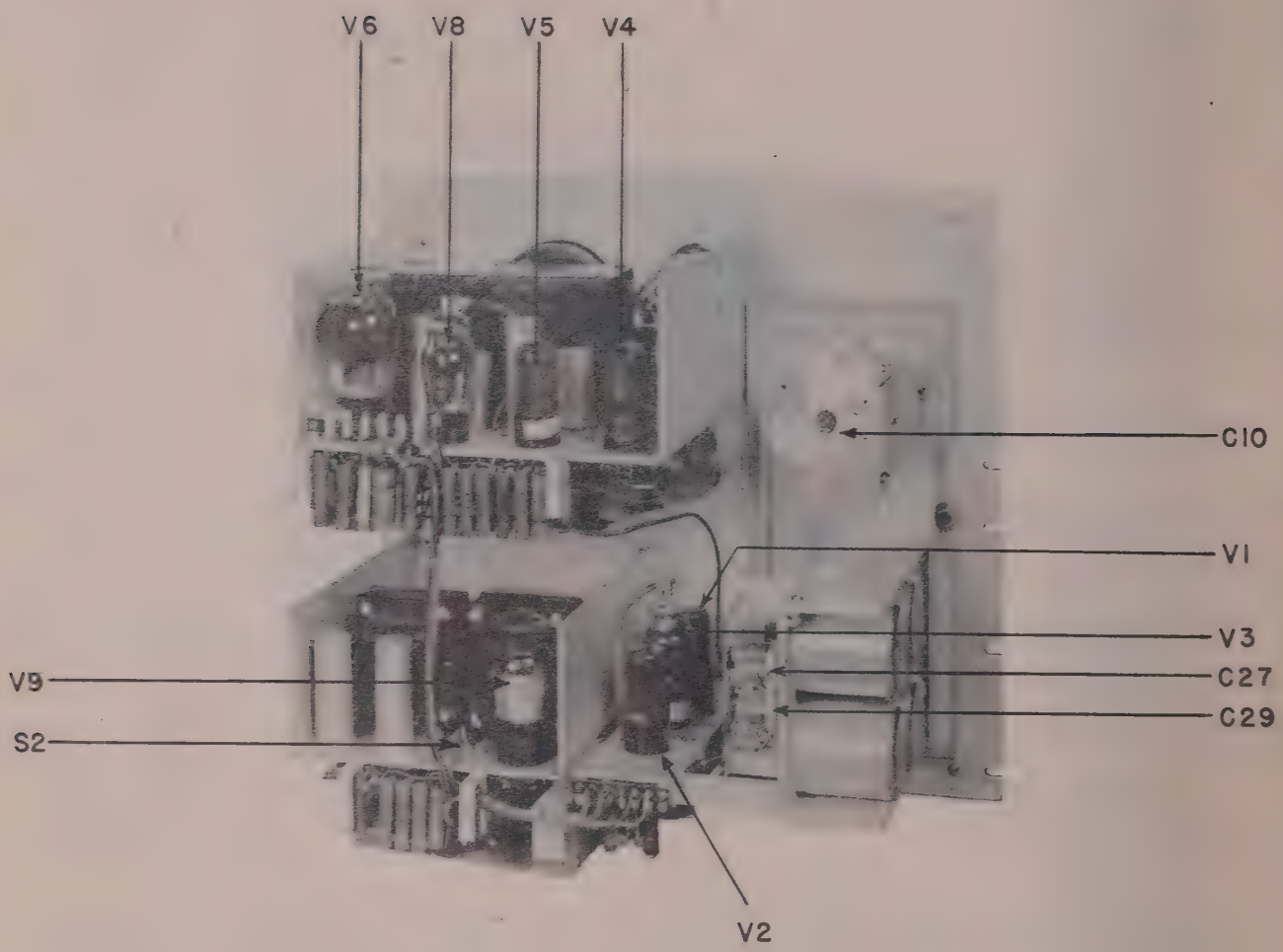


FIG. 2 - REAR VIEW

VOLTAGE SOURCE - 20 cycles to 5 megacycles:- The five resistance steps of the output attenuator (Fig. 2 #S4) are designed to be used as a voltage source. The open circuit voltage across the output terminals is given by the voltmeter reading, multiplied by the attenuator multiplier factor as indicated by control (Fig. 2 #S4). The continuously variable control (Fig. 2 #R28) is provided to enable any voltage falling between attenuator steps to be obtained. Controls #R28 and #S4 should be operated in a manner which produces the greatest voltmeter reading for a given output in order to provide the most accurate voltmeter reading and minimum ripple to signal ratio. The exception to this may occur when it is desired to obtain minimum harmonics and then a lower voltmeter reading may be used. A favorable signal to ripple ratio is maintained down to a reading of 3 volts on the voltmeter but it should be noted that since the control (#R28) is in the grid circuit of the second amplifier tube, there will be a small ripple voltage output but practically no signal if control (#R28) is turned counter clockwise as far as possible.

When feeding impedances high compared to the internal resistance of the resistance attenuator (see page 3) the output voltage is given by the VTVM reading times the attenuator factor.

When feeding lower impedances, the shunting effect of the load impedance on the internal attenuator resistance must be taken into account.

POWER SOURCE - 20 cycles to 5 megacycles:- When turned to the extreme clockwise position, the output control (#S4) connects the output terminals to the plate of the output tube through a large series condenser. The plate voltage to the output tube is supplied by means of a choke system so that a maximum amount of power is available at the terminals of the instrument. Approximately one watt is available in a load of 1,000 ohms resistance at all frequencies.

For resistive loads higher or lower than 1,000 ohms, the available power will decrease in proportion to the increase or decrease in load resistance. Thus one-half watt is available in loads of 500 and 2,000 ohms. While the output control (#R28) may be advanced to give greater output power, the harmonics generated will increase at an accelerated rate.

TRANSFORMER - 20 cycles to 30 kilocycles:- The five transformer taps designated as 20 ohms, 50 ohms, 200 ohms, 500 ohms and 1,000 ohms on the attenuator dial provide power over the low frequency range, that is, from 20 cycles to 30 kilocycles. The impedances indicated are the rated terminal loads to be connected external to the generator. These rated loads are approximate since other

loads may be used. If the load used departs greatly from the rated value, full power output will not be available with low distortion. As a general rule, for low distortion operation, the output should be limited to 1 watt, decreased by the ratio of the actual load to the rated load.

CAUTION:- The output should be reduced by means of control (Fig. 2 #R28) before switching to transformer taps or the power output tap, when the output terminals are unloaded, since otherwise the output voltage may rise to a high value damaging the output voltmeter.

SECTION III

MAINTENANCE

Access to the circuit parts of the instrument may be had by removing the panel mounting screws and sliding the panel forward.

CAUTION:- Upon loosening these screws, the panel will drop slightly in the metal cabinet, that is, until the support block contacts the floor of the cabinet. The panel should then be slid carefully forward and lifted from the cabinet. Care should be taken to avoid damage to any parts, especially the resistors on the rear of the oscillator unit. The panel may be placed on a bench, resting on the support block.

The thermal box covering the oscillator tuning elements may be removed by removing the securing machine screw in the approximate center of the rear of this box and also removing the three wood screws which secure the bottom of the box to the box proper. The main portion of the box may then be removed by carefully sliding it up and off.

In replacing, care should be taken to insure clearing the lead connecting the oscillator unit and the amplifier unit and the various leads below the oscillator tube shelf.

DEFECTIVE TUBES:- The circuits of the instrument have been designed to operate best with selected tubes of average characteristics. Selected modulator and amplifier tubes are available which have been tested for normal gain, plate and screen current and harmonic generation and oscillator tubes for average electrode capacitances. The slight additional cost of selecting average tubes justifies their use in the instrument (see page 6).

The normal life of tubes cannot be accurately estimated and it is recommended that a duplicate set of tubes be kept on hand for use in the event of unsatisfactory performance of this instrument.

A cathode ray tube failing to show a pattern or showing a dark spot in the center of the screen may recover on standing idle. A tube which shows this difficulty repeatedly should be replaced by a standard type 913.

PRECAUTION:- Since it is characteristic of these CR tubes to collect a charge on the screen in the presence of low voltage electrons, it is important that the beam be extinguished by complete counter clockwise rotation of control (Fig 2 #R49) before turning the instrument ON or OFF to avoid failures such as dark spot mentioned above.

OPERATING VOLTAGES:- The following table of normal operating voltages is given to aid in locating tube or circuit troubles. These are average voltages and departures of a few per cent may be regarded as normal:-

Oscillators			Modulator	
High Frequency range	+B	= 122 volts	+B	= 140 volts
-do-	Screen	= 132 volts	Screen	= 140 volts
-do-	Cathode	= 22 volts	Cathode	= 11.5 volts
Low Frequency range	+B	= 55 volts		
-do-	Screen	= 60 volts		
-do-	Cathode	= 6 volts		

Amplifier

	1st Stage	2nd Stage	Output
+B	= 200 volts	235 volts	320 volts
Plate	= 118 volts	195 volts	230 volts
Screen	= 200 volts	235 volts	230 volts
Cathode	= 11.5 volts	14 volts	14 volts

Signal Voltages

At Modulator Plate	1.00 volts	R. M. S.
Across Out.Control	4.5	-do-
At 2nd Amp. Grid	13.2	-do- *
At Out.Amp. Grid	13.	-do- *
Output Voltage	30.	-do- *

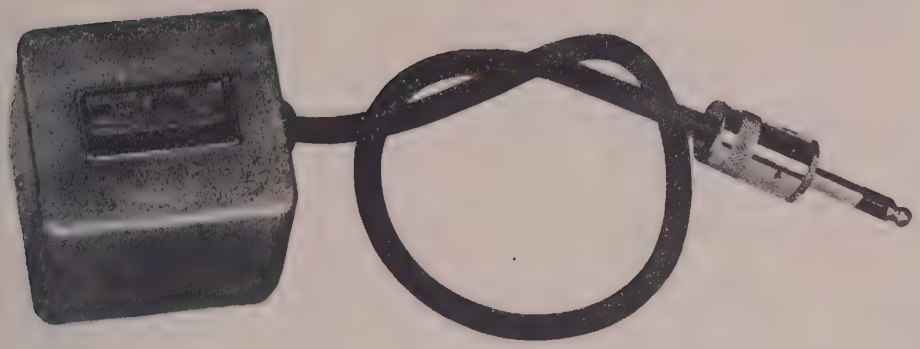
* With output control set for 30 volts across resistance attenuator.

OPERATING NOTES:- An off screen vertical amplitude on the cathode ray tube, when using the tapped transformer, indicates too high an external load impedance. The load impedance should be decreased or a higher impedance position of the transformer should be used.

A slight "singing" of the output choke around 3,000 cycles is not abnormal. In order to keep the capacitance of this choke low the impregnation is light.

Fluctuations or pulsations of the VTVM meter usually indicates fluctuating line voltage and if troublesome this condition may be remedied by using a line voltage regulator delivering 120 watts. (See note on page 7).

OUTPUT UNIT TYPE 144-B

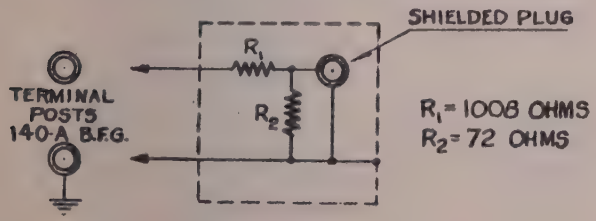


DESCRIPTION

The type 144-B Output Unit has been designed as an accessory unit to match the output of the type 140-A Beat Frequency Generator to a 72 ohm external resistance.

The unit is furnished complete in a shielded box and with a shielded output cable and may be plugged into the output terminals of the Beat Frequency Generator.

The circuit of the unit is shown below:



When this unit is plugged into the output posts of the Generator (with attenuator switch set on "PWR") the open circuit voltage at the shielded plug (or end of shielded cable) is 2 volts when the output of the Generator is so adjusted that the output voltmeter reads 2 volts on the red scale.*

If an external resistance of 72 ohms is connected across the output of the type 144-B Unit, the output voltage will be reduced from 2 volts open circuit, to closely 1 volt (calculated, 1.03 volts) on load.

For any external load impedance values, reactive or resistive, the output voltage may be calculated from a knowledge of the impedances involved.

* NOTE: This special calibration of the VTVM scale, i.e., the red scale, is supplied upon request and when the type 140-A Beat Frequency Generator and type 144-B Output Unit are ordered together. However, the type 144-B Unit may be used with the standard voltmeter calibration in the type 140-A B.F.G. The following calibration points may be used:

B.F.G. Output V.M. reading (black scale) in volts.	Corresponding Open Circuit Output Volts.
30.0	2.0
22.5	1.5
15.0	1.0
etc.	etc.

Dimensions: (less cable) 2½ x 2¼ x 2 inches.

Weight: 8 oz.

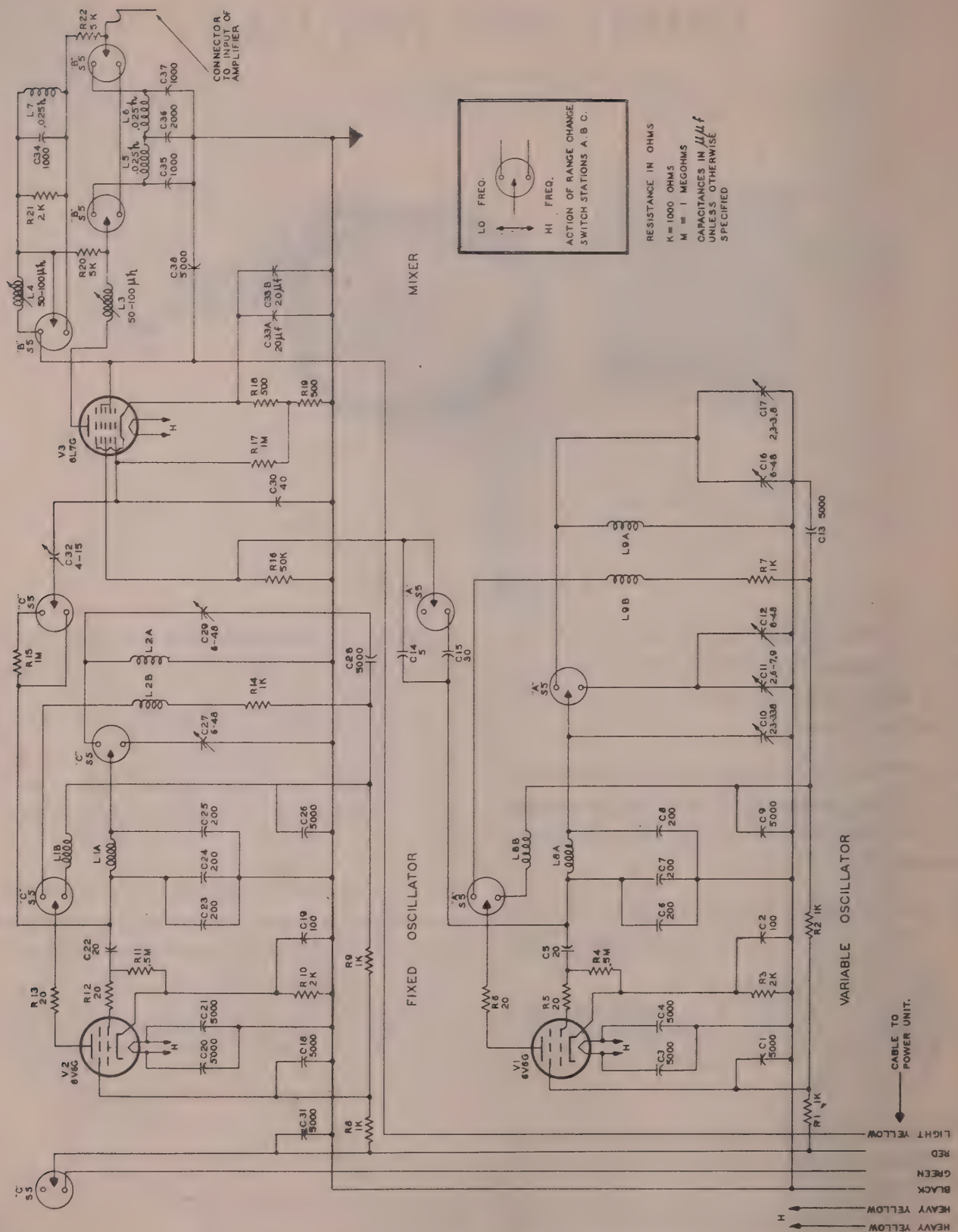


FIG. 3 - OSCILLATOR MIXER - SCHEMATIC

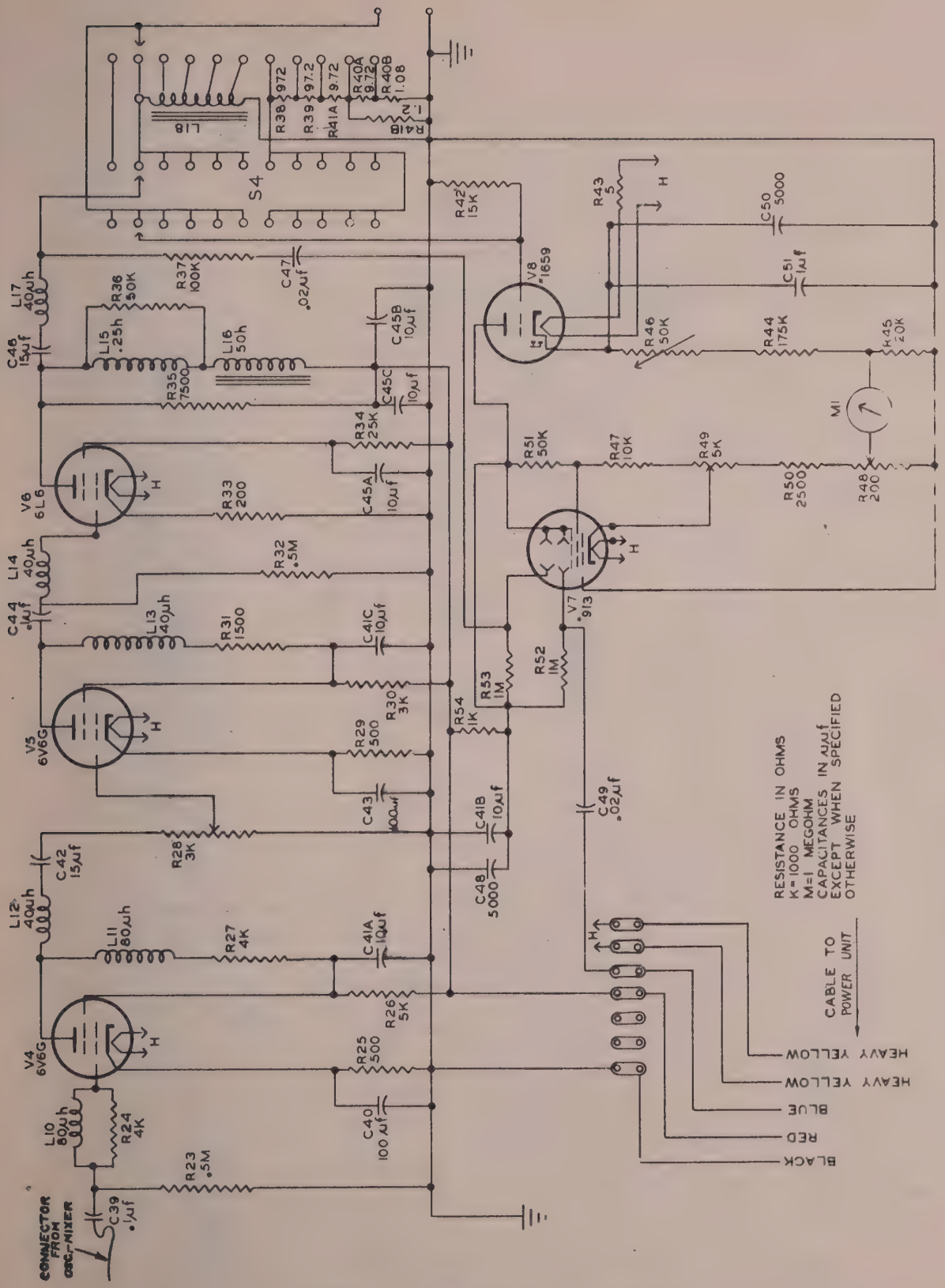


FIG. 4 - AMPLIFIER - SCHEMATIC

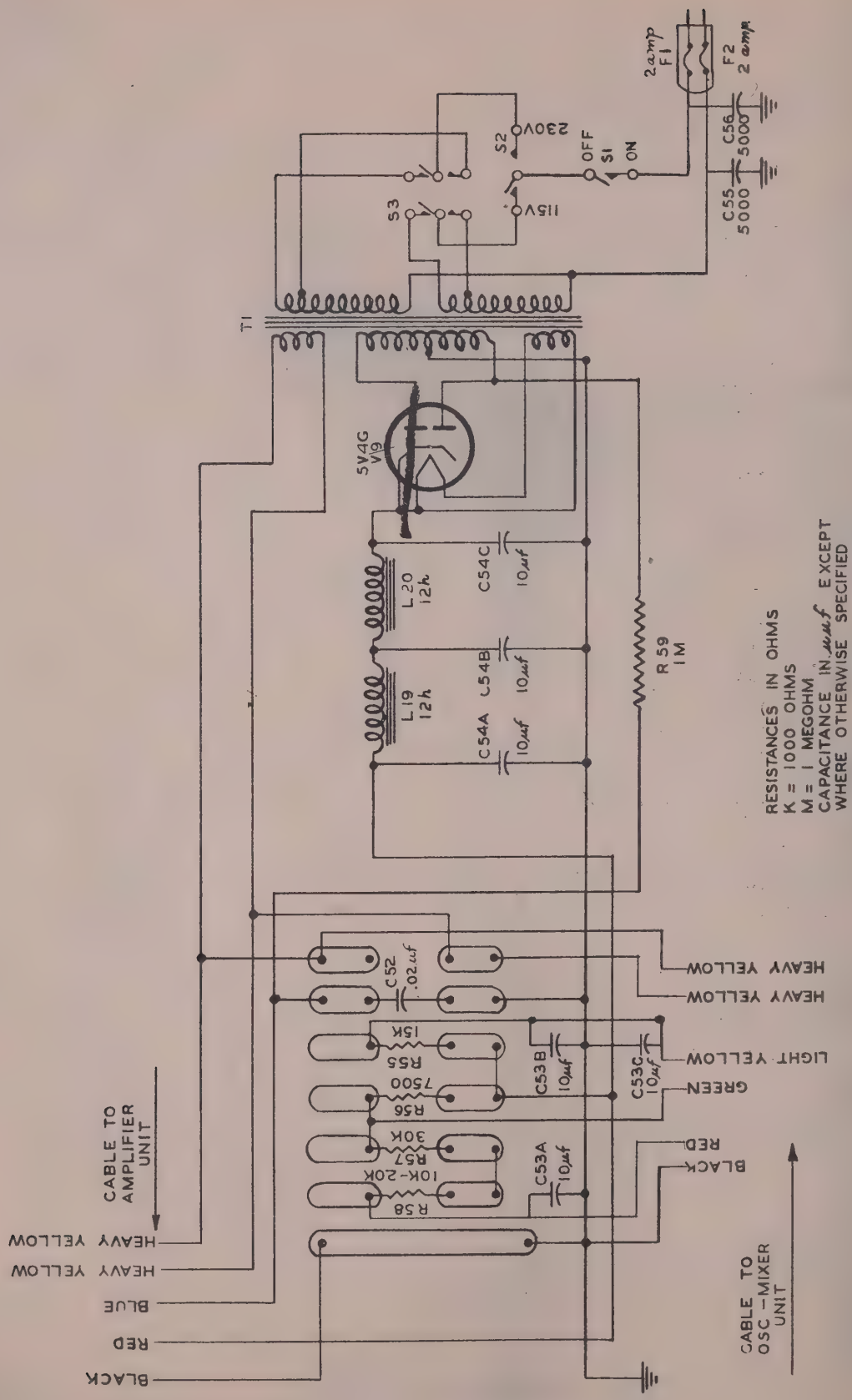


FIG. 5 - POWER UNIT - SCHEMATIC

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